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## FOURTH DIMENSION FOR REPRESENTING AND COMMUNICATING ARCHITECTURAL HERITAGE

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### ABSTRACT:

In the last years dynamic and hyper-medial representations have burst on the scene of the traditionally static architectural representation methods, thanks to the most recent technological developments in the field of computer graphics. Advanced digital media techniques and dynamic representations are establishing as primary emerging modes of architectural representation, using different techniques such as 3D modelling, animations, montage, virtual and augmented realities and other digitally based techniques. This phenomenon has involved, with different aims and results, both the process and divulgation of design and the analysis and documentation of heritage.

Meaning the representation of architectural heritage as a heuristic and interpretative method, and the communication as a conveying of knowledge tool, the introduction of the time dimension acts as a new powerful medium and a suitable tool to interpret the complexity of reality.

In this paper we will develop some considerations about the surplus value by means of fourth dimension, in representation and communication of cultural heritage, referring to its different expressions and levels of immersiveness: animation, interactivity, virtual, mixed and augmented reality.

Animated 3D digital models allow the reconstruction of the historical transformation of a building as well as an urban setting, viewing through its present aspect the different looks it had in the past, and recognizing their traces. This reconstructive representation is a way to understand the object and become an important tool of historic and iconographic research, because it allows reviving a building, whether it is partly or totally lost, or hiding in the body of a stratified building.

With the digital support the model simulates the hypothetical reality, overcomes static limitations and allows interacting with any kind of sign.

In this way the users, the visitors, the scholars of an architecture or of an urban complex can appreciate spaces before, during and after its irreversible transformation.

Aim of this research is to express, starting from the analysis of some case studies, some proposals useful to professionals involved in analysis and representation processes of architectural heritage to increase the communicative and expressive capabilities of their works.

### RÉSUMÉ

Dans les dernières années les représentations dynamiques et hyper médiées ont éclatées sur la scène des méthodes de représentation de l'architecture, traditionnellement statiques, grâce au développement des récentes technologies de l'infographie. Les techniques avancées des médias numériques et les représentations dynamiques sont en train de s'affirmer comme les principales modalités émergentes de la représentation architecturale, à travers l'emploi des différentes techniques comme la modélisation 3D, l'animation, le montage, la réalité virtuelle et augmentée et d'autres techniques basées sur le numérique.

Ce phénomène a impliqué, avec différentes finalités et résultats, soit le processus et la divulgation du projet soit l'analyse et la documentation du patrimoine architectural.

En considérant la représentation du patrimoine architectural comme une méthode heuristique et interprétative et la communication comme un instrument pour transmettre la connaissance, l'introduction de la dimension temporelle agit comme un nouveau puissant medium et en instrument approprié pour interpréter la complexité de la réalité.

Dans cet écrit nous développerons des considérations relatives au surplus de valeur donné par la quatrième dimension, dans la représentation et communication du patrimoine culturel, par rapport aux différentes expressions et degrés d'immersivité.

Le but de cette recherche est exprimer, en partant de l'analyse d'études de cas, des propositions utiles aux chercheurs qui utilisent les représentations dynamiques pour augmenter les capacités heuristiques et communicatives des leurs analyses.

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## 1. INTRODUCTION

In the last years dynamic representations have burst on the scene of the traditionally static architectural representation methods, thanks to the most recent technological developments in the field of computer graphics.

Referring to dynamic representations, it seems important to distinguish between animation of architecture and architectural movie, because they are used to represent different topics and contents, applying the fourth dimension in different ways. While in animation of architecture it is the building, static by nature, which moves for simulating its transformations during the time on front of a static and passive viewer, in architectural movies the camera movement along a defined path around and inside the buildings simulates the eye of the visitor. Sometimes these two dynamic representation techniques are mixed together; in this case animated architectures are viewed by moving spectators.

Animated 3D digital models allow the reconstruction of the historical transformation of a building as well as an urban setting, viewing through its present aspect the different looks it had in the past, and recognizing their traces. This reconstructive representation is a way to understand the object: it becomes an important tool of historic and iconographic research, because it allows reviving a building, whether it is partly or totally lost, or hiding in the body of a stratified building.

With the digital support the model simulates the hypothetical reality, overcoming static limitations and allows interacting with any kind of sign.

In this way not only the researchers, but also the visitors and the scholars of architecture or of an urban complex, can appreciate spaces before, during and after its irreversible transformation.

"The extreme care in implementing 3D reconstructions is the final result of a new attention paid by the stakeholders to the communication capability of ICT, both as for the large audience and the narrow scientific community. We produce representations which are mediated by the experience and culture of the human operator. It was required to the experts to break down the matters taking into account a non-technical audience and to adopt a language as simple as possible. Some issues are addressed at two levels of depth, with a general introduction for non-specialist readers and a more-in-depth treatment addressed to technical experts". (De Francesco, D'Andrea, 2008)

Thanks to digital modelling, the 4D visualization of morphological transformations of the urban fabric as well as of buildings or complexes in various historical periods makes it possible to share this information and diffuse it in a readily understandable form to a wide-ranging spectrum of public.

The era of graphic papers that only the specialists can decipher is over. Movies generated starting from 3D digital models, applied to the historical reconstruction of the cultural heritage, are a powerful medium for verifying the perceptive quality of the virtual visit in space and time. The communication clearness and immediacy could be verified in this respect.

"Regarding to the technical level, digital models consolidate many disperse information and therefore facilitate any decision making prior to intervention. They facilitate the diagnosis of different structures and constructive techniques of the past. They complete and complement the graphic existent documentation with plotting of ruins and vestiges. At the historic level, the models allow to represent the building through the ages, following the succession of interventions.

Finally, from a methodological point of view, models offer elements of analysis for the study, and preservation of the architectural heritage" (Vico, Vassallo, 2008).

In a 3D digital model, the complexity of the representation gives way to an illustrative simplification which has, in any case, better spatial control of the object and far exceeds the traditional static axonometric and perspective forms of representation.

The model thus becomes an essential tool to check and control the validity of reconstructive hypotheses.

As Maldonado affirms "digital models... allow a richer and more controlled interaction between user and model... digital models are able to cover, within a unique representation system, the entire range of possible modelling". (Maldonado 2005)

Additionally, the introduction of the time factor to a certain extent introduces a dynamic element in the representation and in the knowledge of its subject. While the representation that followed the "paper path" refers to a precise moment in history, the representation that unfolds as a succession of images on the screen emerges as a becoming, a process.

"What is lacking presently is both an ontology for visual literacy in the area of virtual heritage, and some method of adding to the viewer's understanding through the supply of supporting information" (Ogleby, 2007).

## 2. REPRESENT AND COMMUNICATE ARCHITECTURAL HERITAGE BY DYNAMIC REPRESENTATIONS

Meaning the representation of architectural heritage as a heuristic and interpretative method, and the communication as a conveying of knowledge tool, the introduction of the dimension time acts as a new powerful medium and a suitable tool to interpret the complexity of reality.

Representation and communication concern the knowledge data, results of documentation and survey phases.

The digital model represents the most useful database to collect and synthesize these analysis phases.

A completed digital 3D processing of acquisition and representation will be the best basis of knowledge according to an integrated approach in order to minimize the risk to lose scientific data (Forte, 2003).

As Ogleby states "there are several conventional' stages in the graphical reconstruction of an antiquity. These include the gathering of source information, the interpretation of this information, the use of contemporaneous example and parallels, the development of a basic geometric wireframe, the addition of detail to this framework and finally the rendering (artistic or otherwise) of the result. This process is common (or should be common) to the generation of imagery regardless of whether a computer is involved". (Ogleby, 2007)

The representation can assume the task to document the researchers' interpretation about the shape generation, the transformation during the time, the building phases and technologies used. All these interpretations are founded on the heuristic analysis of sources and surveys.

"Through the analysis of the most important data and of their correlation with the historical sources it will be possible to get a very detailed idea of the work's original image, but this is still just an idea. Virtual restoration, therefore, becomes the graphic representation of a reconstructed ideal image just as it has formed through the collected data interpretation... Even a very detailed graphic reconstruction, of an architectural product, aimed at giving the viewer a stimulating image of reality, will always necessarily be the result of a synthesis... A synthesis always implies the exploitation of specific aspects to the detriment of others and consequently a data loss". (Galifi, Moretti, Aoyagi, 2002)

The communication aims to show the architectural heritage inserted in the historical settlement, the perceptive effects generated by shapes and materials using a sequence of human-eye perspective views, the reconstruction of buildings “ancient life” by means of furniture, utensils and actors in costume.

Most of these dynamic 3D reconstructions have educational purposes: they are intended to a wide range of not specialized public. For this reason they have to speak a simplified imagery language and be strongly photorealistic.

Besides they are transmitted and diffused by different media: television, websites, cultural film distributors, installations. This means different lengths of movies and different levels of interactivity by the users with the aim to create an experience similar to a real visit, allowing to the viewers to find one’s way. The increasingly enhancements of digital technologies, also in the ambit of renderings and motion graphics, appear in the ability to produce high-level photorealistic imagery: the digital image seems to be photograph of the object. In this way several times photorealism become hyperrealism overcoming the limits of truth likeness.

Therefore we agree that “the real world, or one’s interpretation of the real world, is dirty, cluttered and imperfect and illuminated by complex light sources. If a computer generated image exhibits this, then perhaps it resembles a photograph?” (Ogleby 2007).

## 2.1 Case studies of dynamic 3D reconstruction

While several times digital reconstructive 3D models are created by teams of architects and archaeologists - who generally participated to the survey operations -, texture mapping, lighting, rendering, movie and animation are processed by rendering studios and filmmakers. It involves an exchange of ideas between researchers and experts in Communication Sciences and Cinema Engineering. This engages critical discussions on the ontological nature of films, on their narrative form, and involves the attention of dynamic architectural representations about perceptive aspects produced by the dialectic relationship between people and space.

The production of movie and animation of 3D models has to focus on well organized sequences relating space, event, and movement.

Below we will analyze one video realized to be posted in cultural website as well as in museum installation and for this reason characterized by educative purpose and short duration.



Figure 1. Lattes Archaeological 3D Reconstruction, 2008.  
([http://www.youtube.com/watch?v=6oseC0Yuc94&feature=channel\\_page](http://www.youtube.com/watch?v=6oseC0Yuc94&feature=channel_page))

The short video (1:00) representing the archaeological 3D reconstruction of Lattara, an ancient port town in the south of

France was produced by Bartproject (Ignazio Mottola and Stéphane Valette), starting from the data collected during thirty years of archaeological researches and campaigns of excavations conducted by CNRS/Culture/Université/Inrap.

It has been published in 2008 in the web site of French “Ministère de la Culture et de la Communication”, (<http://www.culture.fr/>).

Viewing the movie, the visitor can discover the possible settlement image in the 6th Century BC and the reconstruction of streets, houses and private spaces. The video starts with an aerial view of the urban setting inserted in the sea natural environment, moving along the main street which connects two of the city gates. Then, the camera assumes the human eye heights accompanying the viewer to see the courtyards and the interiors of the houses livelined by furniture and utensils.

3D model is photorealistically rendered using natural lights and materials. At the opposite pole, referring to the aims - documentary in the previous case, projectual and promotional in the following one - and to the use of imagery language, the film (5:51) for the redevelopment of Jeddah Central District describes a project both for the requalification of historical city centre and the development of the waterfront. For this reason the movie joins images of the existing historic core with others of the new master plan as is resumed in the conclusive slogan “Jeddah Heritage and Modernity”. First part of the movie, about 1:40, is dedicated to the representation of old city centre, starting from an ancient map of Arabia on which sailing ship and caravans head toward Jeddah. Then, some old photographs representing the architectural heritage and the human activities are overlapped by 3D digital models of the same places. These, are now animated by interventions of renovation and transformation of façades and open spaces.

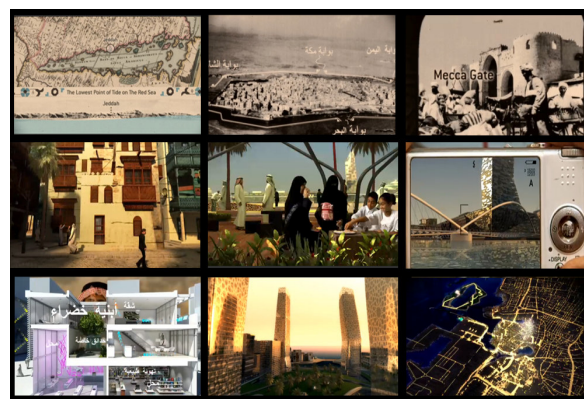


Figure 2. Restoring Historic Jeddah, 2008.  
(<http://www.squintopera.com/#/projects/?id=104>)

The narrative explains the historical importance of the city and makes the case for a sympathetic development, aiming to revitalise the city’s architectural and social inheritance whilst protecting its utterly unique character.

Archive photographs and pictorial representations of the city animated by subtly shifting two-dimensional planes give way to a long and thoroughly impossible, tracking shot in which the viewer’s gaze seems to be the cause of a spectacular regeneration: dilapidate buildings are renovated, roads healed, trees and shades descend to provide comfort in public spaces.

Most of the frames are obtained using post-production procedures that allow to move and to enlarge static images, to insert and blend dynamically different elements such as drawings, photographs, texts, to insert people, trees, symbols...

This fantastic and unscientific reconstruction is typical of the works of Squint/Opera, the group of filmmakers, which proposes videos imaginatively rich, researching an emotional and sensorial experience for the viewers.

Another aim has “The Qumran visualization project”, developed between 2007 and 2008 by Robert R. Cargill under the guide of William Schniedewind in the UCLA Department of Near Eastern Languages and Culture. The work of 3D modelling had for the scholars a meaningful heuristic role in verifying different constructive hypotheses.

Researchers base theory on interactive real-time 3D model of reconstruction of famous complex of Qumran, where the Dead Sea Scrolls were written and hedged in.

Taking the excavated remains as its blueprint, the UCLA team began to model the structure wall by wall, reflecting their thickness, strength and, even, texture.

What the model showed was that the ancient inhabitants of Qumran, had remodelled and expanded the original structure. 3D modelling was essential for discovering and checking between different hypotheses about the origin as a fortress, the additions and the transformations in a monastery for the Essenes, an early Jewish religious community bringing with them the scrolls and continuing to copy and compose new scrolls. With the 3D model, the researchers deconstructed the whole complex piece by piece.

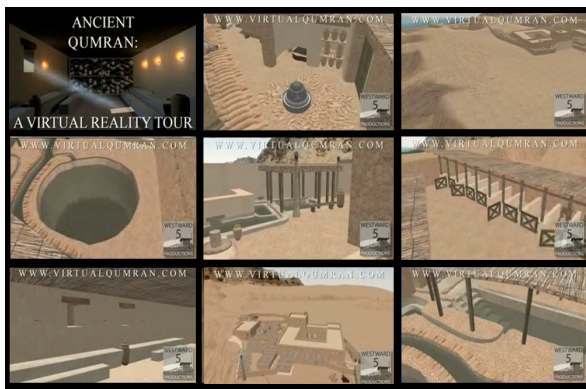


Figure 3. Qumran Reconstructed, 2007-2008.  
(<http://www.virtualqumran.com>)

That allowed them to “see” architectural elements invisible to the naked eye, as Schniedewind affirms: “Once you put all the archaeological evidence into three dimensions, the solution literally jumps out at you... We felt it was of the utmost important to allow the archaeological remains to speak for themselves. So we decided to follow the evidence in modelling the site, no matter where it would lead. In attempting to reconstruct many of the suggestions made by scholars over the years, we found that many were simply not possible architecturally. But when half of the elements were taken from each of the competing theories and added to each other, the most plausible — and buildable — explanation emerged” (New look at Dead Sea scrolls discovery site, 2007).

As the researchers explain, the computer model was built over the course of 15 months using MultiGen Creator, a powerful modelling tool known for producing fully interactive real-time models. Photographs of wood grains, plasters and soil at Qumran and other similar sites throughout the Middle East provide the model's texture.

The model includes virtual recreations of oil lights, ink wells, pottery and other actual artefacts discovered throughout Qumran.

A series of high-resolution panoramic photographs of the sky, the cliffs to the west of the site, the Dead Sea and the plains of Jordan to the east were grafted together in Photoshop to illustrate Qumran's surroundings. The project's architects eventually plan to replace the panoramic photography with satellite imagery, which will allow them to virtually simulate the surrounding topography and terrain. (Virtual Qumran Sheds New Light On Dead Sea Scrolls Discovery Site, 2007).

Eight short movies, created from the real time digital model were posted in the website (<http://www.virtualqumran.com>), and show aerial views of the complex inserted in the desert environment and walks-through inside the reconstructed buildings of the complex.

## 2.2 Future scenarios of developments for architectural heritage dynamic representations

Observing the increasingly introduction of the fourth dimension into the traditionally static representation methods as a new powerful medium and tools in the concept phase of design of which it can become the “engine”, we think that might be developed also the heuristic potentialities in the ambit of digital reconstructive animation and movie.

In the field of architectural research this opportunity is now less used and seems to be underestimated.

We agree with De Francesco and D’Andrea that today “a good reconstruction was weighted for its strong emotional impact or for its interactive and navigable functions rather than for its scientific reliability and trustworthiness. We have hundreds of 3D reconstructions of the most famous ancient sites and for the archaeological areas of greater touristic impact. As a consequence, such products targeted to a very large audience generated an attitude of scarce attention and mistrust by the archaeologist and professionals towards 3D technologies. In fact, the researches didn’t evaluate correctly the added value determined by the availability of 3D object” (De Francesco, D’Andrea, 2008)

In particular it has to value and increase the meaningful projectual aspect of reconstructive simulation as a tool for valuating different hypothesis about the generative shaping process, for verifying the perceptive effects of architectural complexes no more existents or accessible today from different paths, for recognizing the aesthetic ideals of past, for checking the possible hypotheses about building techniques and phases.

At the same time it could be interesting to enhance the information level of the digital reconstruction by means of hyperlinks to different data: explanatory texts, documentary sources, bibliography, survey data, images...

These information could be selected depending from the user, distinguishing between researchers, professionals, scholars and not specialized users.

Referring to the communication it has to value the indubitable potentiality of digital tools in the field of post-production.

As Ogleby affirms “the idea of post-production may not at first appear to have much to do with the generation of output from virtual heritage, but many other processes are available to enrich the experience offered by the images” (Ogleby 2007). Within the vantages offered by post-production procedures he includes: “compilation of images into animations: a better process than just rendering animations allows layers of images to be compiled into a single scene, facilitates transition between scenes, the incorporation of backgrounds and environments, the incorporation of human figures, the addition of audio, soundtracks, background noise, the addition of titles and credits” (Ogleby 2007).



### 3. REPRESENT AND COMMUNICATE ARCHITECTURAL HERITAGE BY VR AND AR REPRESENTATIONS

Virtual Reality aims to generate a whole simulated environment, which surrounds the user; the Augmented Reality is different because its purpose is not to inhibit the vision of the real world, but somehow to enrich, and integrate it.

Augmented Reality (AR) can be defined as an environment in which the vision of the real world is "increased": this is due to the presence of virtual objects. It is very similar to virtual reality, in the sense that both technologies make use of virtual data generated by computer.

Augmented reality is a field of computer research which deals with the combination of real-world and computer-generated data (virtual reality - VR), where computer graphics objects are blended into real footage in real time.

In 1994 Milgram introduced a famous taxonomy to relate the virtual reality and augmented reality as different degrees of perception, in a transition between the real and virtual, as described below. (Milgram, Kishino, 1994).

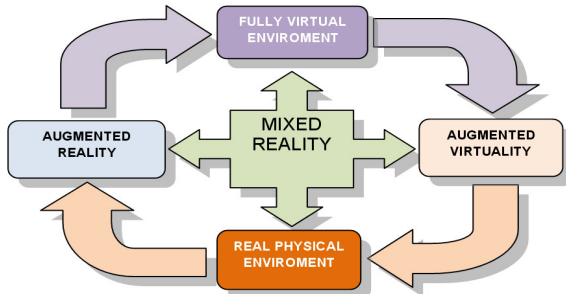


Figure 4. The Virtuality Continuum revisited

The *Virtuality Continuum* is a sentence used to describe a concept that there is a continuous scale ranging between the completely virtual, a Virtual Reality, and the completely real: Reality. The reality-virtuality continuum therefore encompasses all possible variations and compositions of real and virtual objects.

In the examples below we analyze two different case studies of VR and AR applied to cultural heritage.

#### 3.1 Case studies of VR reconstruction

Virtual Reality reconstruction technology offers the opportunity to explore what it has been damaged, destroyed or simply not approachable. This is the case of the Domus Aurea, a large landscaped portico villa, designed to take advantage of artificially created landscapes built in the heart of Ancient Rome by the Roman emperor Nero after the Great fire of Rome, which devastated Rome in 64 AD. Increasing concerns about the condition of the building and the safety of visitors resulted in its closing at the end of 2005 for further restoration work. The complex was partially reopened on February 6, 2007, but closed on March 25, 2008 because of safety concerns.

The digital reconstruction of a part of the Domus Aurea, was commissioned by the Soprintendenza dei Beni Archeologici of Rome to Orange Engineering, an engineering company that is active in many fields, from the town-planning to the architectural restoration, using innovative tools such as 3D animations, interactivity, real time 3d. Nowadays, the virtual exploration of this archaeological site is the only way to appreciate its beauty.



Figure 5. VR real time 3D of Domus Aurea.  
([http://www.orangeengineering.it/real\\_time\\_3d\\_domus\\_aurea.html](http://www.orangeengineering.it/real_time_3d_domus_aurea.html))

#### 3.2 Case studies of AR reconstruction

As in the past, also in this case some technologies created for different purposes could be applied to the architectural and archaeological representation for educational purposes.

An important Italian project, called RealArcheo, is based on Augmented Reality technology, proposing its adoption in the context of cultural heritage. Using RealArcheo technology, it's possible to see in real time, through a laptop display, the real world, enriched with the evidence lost in the past (buildings, sculptures, paintings), the sites of archaeological interest.

The system involves the use of Tablet PC with integrates video camera system for localization (inertial sensors, camera matching): this lets the user to look in any direction and to observe the current state of the ruins enriched by three-dimensional reconstructions of the architectural elements which have disappeared.

The main purpose of the project is the production of a hardware and software system that enriches the usual visit of a cultural heritage with three-dimensional multimedia and interactive items, in order to restore the site to its original appearance, in order to tell its history.



Figure 6. AR technology using RealArcheo

The working principle of the software, currently under development, is based on the routine programming of the most advanced video game action photo: this allows viewing with great fluency and accuracy each virtual element, located exactly over the real vision, thanks to the coordinates of position and observation detected by the sensors.

The technology allows each visitor to "immerse themselves into history", being a useful instrument to visit the site, displaying maps, routes and place names in the area, overlaying this

information directly to the images on the screen. In addition to the integrated camera, (using which the visitor can take real pictures or "increased" ones) the TabletPC device incorporates a system of camera matching, an inertial motion sensors, a digital compass and a 3D graphics processor.

### 3.3 Future scenarios of developments for architectural heritage using AR representations

It's easy to figure that advanced techniques now devoted to other areas may also soon modify the field of architectural and archaeological representation.

Starting from the example of Wikitude technology (a mobile travel guide for the Android platform based on location-based Wikipedia and Qype content), it is easy to figure possible applications for educational purposes such as installations and exhibitions: using these technologies (open mobile phone software stack) applied to mobile (smart phone) the user is able to benefit the advantages of Augmented Reality, directly using an integrated device in his mobile.

This lets to not follow a pre-learning path of certain information (audio) very often linked to a predetermined path.

We can also imagine scenarios for future planning applications of AR figuring, for instance, the event in which a group of architects and archaeologists collaborating in the renovation of an urban site. In order to define guidelines and evaluate the improvements the designers usually gather in front of a monitor or a projector. This mechanism introduces significant limitations: users are forced to use a single point of view and only one person at a time can interact with the virtual building. Participants are forced to work on two separate contexts: the real context, where they communicate with other members of the group, and the virtual one, where they can evaluate their own project proposals.

In a near future the building may first appear as a plastic model, placed on the work table around which gathered the members of the design team. Using the Augmented Reality, each user in possession of a smart phone can move freely in the room, include changes and annotations directly in the AR model displayed by all of the users, or only in his staff, being able to recover some information if necessary; the user could also change the display, according to their specific field.

Doing that it would thus improve both the production capacity, because all the designers could simultaneously work together on the data, and the capacity of the communication system, because the users could work on the same factual information.

Observing the speed with which technologies previously described are able to spread in many fields of digital representation, to renew themselves and almost prematurely to be overcome and replaced by other ones, it's easy to figure that in the near future the Augmented Reality will become an everyday used technology for many studies, simple in its execution and its use.

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